



**Screening Level Ecological Risk Assessment at
IR Program Site 16
(Former Creosote Dip Tank and
Fire Fighting Training Area)**

**Naval Construction Battalion Center
North Kingston, Rhode Island**

Contract No. N62472-92-D-1296
Delivery Order No. 0097

Prepared for

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DRAFT
October 2001
296.0097

QUALITY REVIEW STATEMENT

Contract No. N62472-92-D-1296

EA Project No.: 29600.97.3391

Contract Task Order No. 0097

Activity: Naval Construction Battalion Center (NCBC) Davisville, North Kingstown,
Rhode Island

Description of Report/Deliverable:

Screening Level Ecological Risk Assessment at
IR Program Site 16 (Former Creosote Dip Tank and Fire Fighting Training Area),
NCBC Davisville, North Kingstown, Rhode Island

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In compliance with EA's Quality Procedures for review of deliverables outlined in the Quality Management Plan, this final deliverable has been reviewed for quality by the undersigned Senior Technical Reviewer(s). The information presented in this report/deliverable has been prepared in accordance with the approved Implementation Plan for the Contract Task Order (CTO) and reflects a proper presentation of the data and/or the conclusions drawn and/or the analyses or design completed during the conduct of the work. This statement is based upon the standards identified in the CTO and/or the standard of care existing at the time of preparation.

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ACRONYMS AND ABBREVIATIONS

AUF	Area Use Factor
AWQC	Ambient Water Quality Criteria
BAF	Bio-accumulation Factor
BCT	Base Closure Team
bw	Body weight
COPC	Constituents of Potential Concern
CSM	Conceptual site model
EFANE	Engineering Field Activity Northeast
Ff	Food ingestion rate
HQ	Hazard Quotient
kg	Kilogram(s)
mg	Milligram(s)
NCBC	Naval Construction Battalion Center
NOAEL	No-Observed-Adverse-Effects-Level
PAH	Polycyclic aromatic hydrocarbons
RIDEM	Rhode Island Department of Environmental Management
ROC	Receptor of Concern
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific Management Decision Point
TRV	Toxicity Reference Value
U.S. EPA	U.S. Environmental Protection Agency

1. SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

EA Engineering, Science, and Technology has been retained by the U.S. Navy Engineering Field Activity Northeast (EFANE) to provide risk assessment services for the former Naval Construction Battalion Center (NCBC) Davisville facility in North Kingstown, Rhode Island. This report presents the Screening Level Ecological Risk Assessment (SLERA) for the Phase I Remedial Investigation (RI) for Installation Restoration (IR) Program Site 16 (Site 16).

The purpose of the SLERA is to determine if, under expected exposure conditions, chemicals detected in soil, seep sediment, and seep water samples collected from Site 16 are at concentrations that may cause unacceptable risk to organisms using the area.

The key guidance followed in this SLERA are the *Navy Policy for Conducting Ecological Risk Assessment* (U.S. Department of the Navy 1999) and *Ecological Risk Assessment Guidance for Superfund* [U.S. Environmental Protection Agency (U.S. EPA) 1997]. These two approaches are very similar in that they are based on a tiered, step-wise protocol. Assessment methodologies are described in the *Final Work Plan, Remedial Investigation of IR Program Site 16 (Former Creosote Dip Tank and Fire Fighting Training Area), Naval Construction Battalion Center, North Kingstown, RI* (EA 2000). Some tables and figures in this SLERA were incorporated directly from the Work Plan.

Tier 1 of the screening-level ERA consists of two components:

- (1) Problem formulation and ecological effects evaluation (Step 1)
- (2) Exposure estimate and risk characterization (Step 2).

Navy policy adds a refinement, termed Tier 2, Step 3a, of the conservative exposure assumptions used in Tier 1, that leads to an exit criteria evaluation. The Navy procedure is shown in Figure 1. In this SLERA, Step 3a is implemented in the form of a refined food-web model.

U.S. EPA (1997) guidance includes progress reviews at various points in the conduct of Superfund ecological risk assessments. These are termed Scientific Management Decision Points (SMDPs) and involve discussion between risk assessment and risk management teams to approve or redirect the assessment. At the NCBC, the risk assessment and management teams are incorporated under the purview of the Base Closure Team (BCT), which includes U.S. EPA, Rhode Island Department of Environmental Management (RIDEM), and Navy representatives, and other stakeholders. Submission of this draft SLERA to the BCT represents initiation of the first SMDP.

1.1 PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION

Problem formulation represents the scoping stage of the SLERA, and consists of the following elements:

- Environmental setting of the site
- Identification of receptors of concern
- Development of a conceptual site model (CSM)
- Assignment of assessment and measurement endpoints.

1.1.1 Environmental Setting of Site 16

Site 16 is located adjacent to Allen Harbor in the eastern portion of NCBC Davisville (Figures 2 and 3). The Site was the location of a former creosote dip tank area, where, during the 1960s, wood piles were dipped into tanks containing creosote and staged in the area to dry. In addition, a former fire fighting training area was reportedly located at the Site. In such an area, temporary structures were doused with flammable materials, ignited, and fire fighters then put these fires out. Such an operation could have released chemicals to the soil and ground water under Site 16. Currently the land is not used, and consists of the remnants of these former activities. Future land use plans include commercial/industrial development.

A site visit was conducted on 7 October 1999 to identify potential complete exposure pathways that may exist on Site 16, and to characterize the environmental setting with respect to habitat. The majority of the Site 16 shoreline abutting Allen Harbor is highly modified where large boulders had been placed for shoreline stabilization. Non-hydric plants dominated this rip rap area, and site-visit participants agreed that the area lacked wetland characteristics. A small area of *Spartina alterniflora* marsh existed in the northeast portion of the Site abutting Allen Harbor. The majority of the Site contained upland habitat with a vegetative cover of bushes and small trees with localized areas of asphalt paving. The majority of the Site provides good habitat for several terrestrial plant, mammal, and bird species. Autumn olive (*Elaeagnus umbellata* L.), multiflora rose (*Rosa multiflora*), Northern bayberry (*Myrica pennsylvanica*), eastern red cedar (*Juniperus virginiana* L.), and Asiatic bittersweet (*Celastrus orbiculatus*) were common vegetative species. The areas of dense vegetation would provide good cover and food for white-tailed deer (*Odocoileus virginianus*) and Eastern cottontail (*Sylvilagus floridanus*). Wildlife observations made while onsite included: Eastern cottontail, Northern mockingbird (*Mimus polyglottos*), Northern cardinal (*Cardinalis cardinalis*), house finch (*Carpodacus mexicanus*), mute swan (*Cygnus olor*), bank swallow (*Riparia riparia*), Canada goose (*Branta canadensis*), glaucous gull (*Larus hyperboreus*), and great black-backed gull (*Larus marinus*).

1.1.2 Identification of Receptors of Concern

Ecological Receptors of Concern (ROCs) are species or guilds of species that are important to the ecology of the study area and that may be susceptible to chemical constituents detected at the Site. Based on observations made during the site visit, and potential contaminant pathways identified and incorporated into the CSM (Subsection 1.1.3), the following ROCs and associated exposure pathways were identified:

- Marine invertebrates and fish—direct contact with seep water and/or seep sediment

- Terrestrial plants and invertebrates—uptake and/or direct contact with surface soil
- Omnivorous birds (American robin)—dietary ingestion of contaminated food items and incidental soil
- Herbivorous mammals (Eastern cottontail)—dietary ingestion of contaminated food items and incidental soil
- Carnivorous mammals (red fox)—dietary ingestion of contaminated food items and incidental soil.

1.1.3 Conceptual Site Model

The CSM for the Site 16 SLERA is illustrated in Figure 4. The model incorporates key elements of problem formulation including contaminant sources, fate and transport, exposure pathways, and exposure mechanisms. For most receptors, the primary exposure is via surface soil, either by direct contact or via dietary routes. Potential risk to marine fish and plankton is evaluated by screening against seep water concentrations; i.e., a direct contact route. This is highly conservative since dilution in Allen Harbor water is not considered. Potential risk to marine invertebrates, or benthos, is evaluated relative to chemical concentrations in sediment.

1.1.4 Assessment and Measurement Endpoints

U.S. EPA (1997) guidance states that assessment endpoints—defined as “an explicit expression of the environmental value that is to be protected”—must be selected in an ecological risk assessment. Testable hypotheses and measurement endpoints are developed to evaluate threats to the assessment endpoints. Assessment endpoints and testable hypotheses were developed for the Site 16 SLERA (Table 1). The assessment endpoints identified cover a broad range of trophic levels from terrestrial plants and invertebrates to marine fish and plankton to birds and mammals. Measurement endpoints involve screening of media concentrations for the lower trophic levels, and food-web exposure assessment for the higher (bird and mammal) trophic levels.

1.2 ENVIRONMENTAL EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION

Step 2 of the Tier 1 process consists of two components (U.S. Navy 1999; U.S. EPA 1997): (1) exposure assessment; and (2) risk characterization. In this SLERA, exposure is based on the maximum concentration of a chemical detected in any of the sampled media (surface soil, seep water, and seep sediment). Risk characterization is based on calculation of the Hazard Quotient (HQ):

$$HQ = \text{maximum site concentration/screening benchmark}$$

If the site concentration is higher than the screening benchmark, the HQ is greater than 1.0, and potential risk is inferred. If the site concentration is lower than the screening benchmark, the HQ is less than 1.0, and no risk is inferred. As described in the next section, benchmarks are specific to the environmental medium, ROC, and pathway involved. For example, screening benchmarks for

Site 16 seep water are National Ambient Water Quality Criteria (AWQC). In the case of food-web analysis, benchmarks are in the form of body-weight normalized doses referred to as Toxicity Reference Values (TRVs). To the fullest extent possible, all benchmarks are based on No-Observed-Adverse-Effects-Level (NOAEL) toxicological studies.

The initial step in exposure assessment and risk characterization is referred to as the Constituent of Potential Concern (COPC) screening.

1.2.1 COPC Screening Approach

In the Tier 1 process, the COPC screen serves two purposes. First, it serves as the risk calculation for lower trophic level terrestrial organisms (plants, invertebrates) and aquatic organisms. Second, the surface soil COPC screen not only identifies potential risk to plants and invertebrates, but the results are also used to identify chemicals that may pose risk to higher trophic level terrestrial organisms (mammals and birds). That is, any HQs exceeding 1.0 from the surface soil COPC screen are considered a potential threat to higher trophic organisms and are carried into the food-web analysis.

The screening benchmarks used in the COPC screening are listed in Table 2. This list has been updated from that provided in the Remedial Investigation Work Plan (EA 2000), as stated in the following sentences. Analytes not detected in an environmental medium at Site 16 were removed from the list. Also, at the request of U.S. EPA Region 1, several recent references were reviewed to replace some of the older benchmarks from the original list and to provide benchmarks previously listed in the Site 16 Work Plan as "no data." Wherever possible, the soil-screening benchmarks from Oak Ridge National Laboratory were used, either for plants (Efroymson et al. 1997a) or invertebrates or microbial processes (Efroymson et al. 1997b). Dutch values (RIVM 1994, 1997, 2000) were also commonly used, and other sources were employed as necessary (Table 2). If available, marine chronic AWQC were used to screen seep water. If AWQC were not available, the benchmark data of Buchman (1999) and Suter (1996) were used. The latter permitted filling some data gaps in the original list, but these are freshwater benchmarks and thus add some uncertainty to the screening process. Seep-sediment-screening benchmarks were primarily Effects Range Low (ERL) benchmarks from Long and Morgan (1990) and Long et al. (1995), with other sources used as necessary.

Note that essential nutrients (calcium, iron, magnesium, potassium, and sodium) were not screened in any medium. Also, aluminum was not screened in surface soil because all soil pH measurements were 5.5 or higher, following U.S. EPA (2000) recommendations.

1.2.2 COPC-Screening Results: Exposure and Risk Characterization for Lower Trophic Level Terrestrial Organisms and Aquatic Organisms

Surface Soil

Sampling locations are shown in Figure 3 and analytical results are illustrated in Table 3. A total of 51 analytes were detected in surface soil samples. For a relative few of these analytes, HQs exceeded 1.0. These were designated as COPC. The COPC included three metals and eight polycyclic aromatic hydrocarbon (PAH) compounds. Although none of the HQs were very high (none approached 10.0), the conservative nature of the Tier 1 screening requires the presumption of

potential risk to terrestrial plants and/or invertebrates. These results will be reviewed by the BCT in the SMDP process.

Note that no screening benchmarks were available for six organic constituents (dioxin/furan, carbazole, dibenzofuran, 2-butanone, acetone, and methylene chloride). Risk to terrestrial plants and invertebrates cannot be assessed in these cases, and this must be considered in the uncertainty assessment of the SLERA. (In terms of the soil-based COPC being used to trigger food-web analysis, analytes with no screening benchmarks were considered default COPC, and carried into the food-web evaluation.)

Seep Water

Water samples from the two ground-water seeps¹ at Site 16 adjacent to Allen Harbor (Figure 3) were screened against appropriate benchmarks (Table 4). This is a worst-case assessment, since the benchmarks are designed to protect fish and plankton, and these do not reside in the seeps. No dilution with Allen Harbor water is incorporated into this assessment. Three inorganic and four organic analytes were designated as COPC. Several HQs were relatively high, particularly for barium (HQ=71.4) and manganese (25.4). These HQs were based on freshwater benchmarks (Suter 1996), thus increasing uncertainty. Given the exceedance of screening benchmarks for several analytes in the undiluted seep water, a potential risk is inferred to fish and plankton in Allen Harbor.

Seep Sediment

The three sediment samples evaluated here were collected in association with the two seeps described above, and the drainage outfall pipe (OPW16-01, Figure 3). These locations receive drainage from the seeps and outfall pipe themselves, but also, due to tidal flushing, rain, or other factors, may be influenced from other areas of Site 16. For these reasons, sediment from below the drainage outfall pipe was included in this assessment (i.e., whereas outfall pipe water is not influenced by Site 16, sediment below the outfall could be). Fifty analytes were detected among these sediment samples, 27 of which produced HQs greater than 1.0 in the screen, and were therefore designated as COPC (Table 5). Several of these COPC had notably high HQs, including acenaphthene (56.6), fluorene (30.5), dieldrin (85), and endrin ketone (80). Based on the number of COPC, and the magnitude of HQs for some of them, these sediment locations represent risk to marine benthic fauna. The extent to which these locations—all of which receive drainage from seeps or the outfall pipe—are representative of all shoreline sediment at Site 16 is unknown.

1.2.3 Conservative Food-Web Analysis

Approach

The Tier 1, Step 2 analysis incorporates a conservative food-web exposure and risk evaluation. Dietary doses of COPC are calculated and compared to TRVs to estimate risk to higher trophic level terrestrial mammals and birds. The ROCs chosen for food-web analysis at Site 16 are the herbivorous Eastern cottontail, omnivorous American robin, and carnivorous red fox. The

¹ These samples do not include the drainage outfall pipe (OPW16-01, Figure 3) because its source is offsite (stormwater runoff from an adjacent parking lot), and unrelated to Site 16.

conservative food web is so named because of key assumptions: (1) COPC concentration in food is assumed to be the same as in dry weight soil samples; (2) ROCs receive 100 percent of their diet from the Site (area use factor [AUF]=1.0); and (3) COPC are 100 percent bioavailable. These conservative assumptions protect against false negative conclusions; i.e., projecting no risk from a COPC when in fact there is risk, per U.S. EPA (1997) guidance.

Dietary exposures for ROCs have been estimated as body-weight-normalized daily doses for comparison to a body-weight-normalized daily dose TRV. The daily dose for a given receptor of a given COPC is determined by summing the products of feeding rate and food items and multiplying the sum by the total feeding rate and a habitat usage factor [assumed to be 100 percent (1.0) in this conservative food web]. Separate doses are presented for soil and food contributions, and these are summed to produce the total dose for each ROC. The model is described below.

$$Dose_{total} = Dose_{food} + Dose_{soil}$$

where:

- $Dose_{total}$ = Total daily dose of COPC received by receptor; mg COPC/kg-body wt/day
- $Dose_{food}$ = Daily dose of COPC received by receptor; mg COPC/kg-body wt/day from food items
- $Dose_{soil}$ = Daily dose of COPC received by receptor; mg COPC/kg-body wt/day from incidentally ingested soil

The total dose from food is given by:

$$Dose_{food} = F_f \times U \times C_f$$

where:

- F_f = Total daily feeding rate in kg food/kg-body weight of ROC/day (wet basis)
- U = Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web
- C_f = Concentration of COPC in food; assumed to be the same concentration as soil (mg chemical/kg food)

The total dose from incidental soil is given by:

$$Dose_{soil} = F_s \times U \times C_s$$

where:

- F_s = Total daily incidental soil feeding rate in kg soil/kg-body weight of ROC/day (wet basis)
- U = Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web
- C_s = Concentration of COPC in soil; mg chemical/kg soil (dry basis)

Lastly, the total daily incidental soil feeding rate is given by:

$$F_s = F_f \times F_{xsoil}$$

where:

- F_s = Total daily incidental soil feeding rate in kg soil/day (wet basis)
- F_f = Total daily feeding rate in kg food/day (wet basis)
- F_{xsoil} = Fraction incidental soil ingestion as a proportion of food ingestion rate

Information necessary for calculation includes organism body weight (BW), food ingestion rate (F_f), fraction incidental soil ingestion as a proportion of food ingestion rate (F_{xsoil}) and analyte concentrations of ingested materials. As stated previously, vegetation and animal food items were represented by the same concentration as detected in soil samples (dry weight).

Information specifically relevant to the ecology of the ROCs (i.e., body weights, food ingestion rates, and incidental soil ingestion rates) (Table 6) was obtained from published sources. The primary source used for these exposure parameters was the Exposure Factors Handbook (U.S. EPA 1993).

Risk characterization for the food-web analysis is calculated similarly to the media screening:

$$HQ = \text{dietary dose of COPC/TRV}$$

If the dietary dose is lower than the TRV, the HQ is less than 1.0 and no risk is inferred. If the dietary dose is higher than the TRV, the HQ is greater than 1.0, and some potential level of risk is inferred. The TRVs used are NOAEL-based dietary doses obtained from the U.S. Navy EFANE soil-screening database, which in turn were based largely on toxicological data from Oak Ridge National Laboratory (Sample et al. 1996). The TRVs used are listed in Table 7.

Example Food-Web Exposure and Risk Calculation

The example HQ calculation provided below estimates the potential for risk to the red fox exposed to surface soil containing a concentration of lead.

Assume a hypothetical maximum concentration of lead reported in surface soil (dry weight basis) was determined to be 40.9 mg/kg. The only food item for the red fox will be soil.

The following equation provides the dose to the receptor from food ingestion:

$$Dose_{food} = \frac{F_f \times U \times C_f}{BW}$$

$$= (0.320 \text{ kg/day} \times 1.0 \times 40.9 \text{ mg/kg}) / 5.0 \text{ kg}$$

$$= 2.6176 \text{ mg/kg-bw/day}$$

where:

- F_f = Total daily feeding rate in kg food/day (wet basis) (Table 6)
- U = Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web
- C_f = Concentration of COPC in soil
- BW = Body weight of ROC (kg) (Table 6)

The dose from incidental soil ingestion is calculated using:

$$Dose_{soil} = \frac{F_s \times U \times C_s}{BW}$$

$$= (0.0090 \text{ kg/day} \times 1.0 \times 40.9 \text{ mg/kg}) / 5.0 \text{ kg}$$

$$= 0.0736 \text{ mg/kg-bw/day}$$

where:

- F_s = Total daily soil feeding rate in kg soil/day (wet basis) (Table 6)
- U = Habitat usage factor (fraction of habitat range represented by site) for receptor; assumed to be 1.0 for this food web
- C_s = Concentration of COPC in soil; mg chemical/kg soil (dry basis)
- BW = Body weight of ROC (kg) (Table 6)

The final dose is calculated as follows:

$$Dose_{total} = Dose_{soil} + Dose_{food}$$

$$Dose_{total} = 0.0736 + 2.6176$$

$$Dose_{total} = 2.69 \text{ mg/kg-bw/day}$$

The hazard quotient is calculated from the dose and the NOAEL-based TRV (Table 7) as follows:

$$HQ = \frac{DOSE}{TRV_{NOAEL}}$$

$$HQ = \frac{2.69 \text{ mg / kg / day}}{4.22 \text{ mg / kg / day}}$$

$$HQ = 0.6377$$

Site 16 Conservative Food Web Results

The results of the conservative food-web analysis are displayed in Tables 8, 9, and 10 for the Eastern cottontail, red fox, and American robin, respectively. In each case, several HQs exceeded 1.0, and thus reflect potential risk. The cottontail had nine HQs greater than 1.0, but most were relatively low. Only the dioxin toxicity equivalent HQ exceeded 10. The fox reflected fewer HQs greater than 1.0, most relatively low. Only the dioxin toxicity equivalent HQ exceeded 2.0. For the robin, only four HQs could be calculated, because of a lack of avian TRV data for PAH and other organic compounds. Robin HQs for metals were higher than those of the other ROCs (Table 10). This is likely due to the high food ingestion rate of the robin (greater than 100 percent of its body weight per day) and relatively high incidental soil ingestion rate (10 percent of food ingestion rate).

In many SLERAs, the conservative food-web results are the sole estimates of risk to higher trophic level ROCs. These are the results that are carried into the SMDP for discussion between risk assessors and managers. However, U.S. Navy policy for ecological risk assessment (U.S. Navy 1999) affords the opportunity to refine the food-web risk characterization using more realistic assumptions. This is termed Tier 2 Step 3a in Navy guidance (Figure 1), and is implemented in the following section for Site 16.

1.2.4 Step 3a Refined Food-Web Analysis

The refined food web is based on the same model described in the last section, but differs in three important aspects:

- (1) Realistic Area Use Factors (AUF) are employed to provide a more realistic estimate of the amount of time an ROC may spend foraging on Site 16. In this assessment, only the AUF for the red fox differs from the conservative model. The fox's home range is considerably larger than Site 16, whereas the home ranges of the cottontail and robin are smaller than Site 16.

- (2) COPC concentrations in food items and incidental soil were converted to a wet weight basis to reflect conditions in the natural environment, as recommended by U.S. EPA (1993).
- (3) Where available, Bio-accumulation factors (BAFs) were employed to estimate COPC concentrations in food items (Table 11). Many chemicals are found in much lower concentrations in food items relative to soil; use of BAFs provides a more realistic exposure (dose) calculation. When BAFs were not available, the default value of 1.0 was used.

The results of the refined food-web analysis are displayed in Tables 12, 13, and 14 for the Eastern cottontail, red fox, and American robin, respectively. The impact of the Step 3a refinements is immediately obvious—there has been a substantial reduction in the magnitude of HQs and the number exceeding 1.0. No suggestion of risk remains for the cottontail or red fox. The refinements, and in particularly the AUF of 0.006 for the fox (Table 6) have reduced HQs to very low levels. Robin HQs for chromium, lead, zinc, and dioxin toxicity equivalent remain greater than 1.0 in the refined assessment, but have been reduced by about 50 to 80 percent, depending on analyte.

Overall, the perception of risk to terrestrial birds and mammals reflected in the conservative food web has been reduced to a *de minimus* level by the Step 3a refinement.

1.2.5 Uncertainty

Ecological risk characterization includes analysis of uncertainty (U.S. EPA 1997). Uncertainty is distinguished from variability, and arises from lack of knowledge about factors associated with the study. In a screening-level assessment such as this one, uncertainty typically stems from two study facets: the sampling plan and the toxicological data. Sources of uncertainty can include the process of selecting COPCs, assumptions made in establishing the CSM, adequacy of ecological characterization of the Site, estimates of toxicity to receptors, and selection of model parameters. There are a number of factors that contribute to uncertainty in the ecological risk characterization for Site 16, as described below.

- Environmental media are typically sampled in a non-random fashion. That is, sampling points are chosen to best characterize known or suspected areas of contamination. Peripheral and nearby areas are undersampled, if at all, and thus the average exposure of ecological receptors is biased high. This is particularly true of the use of seep water and sediment samples to represent broader open water and sediment environments in Allen Harbor within which two marinas are also located.
- A Tier 1 ERA (SLERA) uses the maximum measured concentration to estimate risks consistent with guidance, which represents a high bias in exposure to ROCs.
- Toxicological data used in the risk characterization represent significant uncertainty. Because there may be no known data on the effects of chemical constituents on

specific ROCs, some chemicals are not screened at all, or toxicological data for surrogate species are sometimes used, and this adds uncertainty.

- Food-item concentrations were overestimated in the conservative food web. The extremely conservative assumption was made that all food (vegetation, soil invertebrates, etc.) was at the same concentration as the dry-weight soil maximum, and 100 percent bioavailable. The resulting high uncertainty was greatly reduced in the refined food web. However, some uncertainty remains due to the use of literature-based BAFs or conservative default values in lieu of onsite tissue concentrations.
- The toxicological data that underpin the screening values are inherently uncertain because laboratory data are extrapolated to specific field sites such as Site 16. This uncertainty is to some extent controlled by choosing the lowest available screening values, consistent with U.S. EPA (1997) guidance to “be consistently conservative in selecting literature values...” This also contributes to overestimation of risk.

Although the direction of bias of some uncertainties is unknown, the overriding influence of the non-random media sampling and assumptions of 100 percent bioavailability assures that risks are overestimated for lower trophic level terrestrial organisms, aquatic organisms, and terrestrial birds and mammals in the conservative food web. Uncertainty surrounding risks to terrestrial birds and mammals was greatly reduced by the refined food web. Some uncertainty remains, however, associated with literature-based BAFs and toxicological data.

1.3 SUMMARY OF SITE 16 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

The results of the various screening assessments and food-web evaluations presented above are compiled and summarized in Table 15. This was done to create a context where potential risk from all environmental media to all receptors can be evaluated at the same time.

Exposure to contaminants detected in surface soil reflects some potential risk to terrestrial plants and invertebrates and—based on the conservative food web—to terrestrial mammals and birds. There are a number of HQs > 1 for terrestrial plants and invertebrates; none is very high, suggesting a low potential for risk to these receptors. Soil-based risks to terrestrial mammals and birds, potentially significant based on the conservative food web, virtually disappeared with the application of the refined food web.

The screening assessments in the aquatic environment indicated the potential for risk to fish and plankton in Allen Harbor from seep water and to benthos from seep sediment. Relatively few HQs in seep water exceeded 1.0, but barium and manganese were relatively high. There is a substantial high-bias uncertainty in this assessment because the target ROCs, fish and plankton in Allen Harbor, would not encounter such concentrations once the seep water entered and was diluted within Allen Harbor. The seep sediment results represent potential risk to marine invertebrates in the benthic community, particularly from manganese and several PAH and

pesticide compounds. It has not been determined whether the seep sediment areas represent localized concentrations of COPC, or whether the data reflect general sediment conditions throughout the Site 16 shoreline area.

1.4 REFERENCES

- Bechtel Jacobs. (1998). *Empirical Models for the Uptake of Inorganic Chemicals From Soil by Plant*. Bechtel Jacobs Company LLC, Oak Ridge National Laboratory. Report BJC/OR-133.
- Beyer, W.N. 1990. *Evaluating Soil Contamination*. U.S. Fish and Wildlife Service Biological Report 90(2). Washington, D.C. 25 pp.
- Buchman, M.F. 1999. *NOAA Screening Reference Tables*. NOAA HAZMAT Report 99-1. Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, Seattle, Washington.
- EA Engineering, Science, and Technology. 2000. *Work Plan, Remedial Investigation of IR Program Site 16 (Former Creosote Dip Tank and Fire Fighting Training Area) Naval Construction Battalion Center North Kingston, RI*. Prepared for Northern Division Naval Facilities Engineering Command, Lester, Pennsylvania. Prepared by EA Engineering, Science, and Technology, Inc., Bedford, Massachusetts.
- Efroymson, R.A., M.E. Will, G.W. Suter, and A.C. Wooten. 1997a. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*. Oak Ridge National Lab Report ES/ER/TM-85/R3.
- Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision*. Oak Ridge National Lab Report ES/ER/TM-126/R2.
- Jones, D.S., G.W. Suter II, and R.N. Hull. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision*.
- Long, E.R., D.D MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19(1): 81-97.
- Long, E.R. and L.G. Morgan. 1990. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program. National Oceanic and Atmospheric Administration Technical Memorandum NOS OMA 52, Rockville, Maryland.
- New Jersey Department of Environmental Protection. 1987. Summary of Approaches to Soil Cleanup Levels. Division of Waste Management, 32 East Hanover Street, Trenton, New Jersey.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. *Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario*. ISBN 0-7729-9248-3. Ontario Ministry of the Environment and Energy. Toronto, Canada.

Quebec Ministry of the Environment. 1988. *Contaminated Sites Rehabilitation Policy. Directorate of Dangerous Substances*. Envirolq. 880100. ISBN 2-550-18630-3. Sainte-Foy, Quebec, Canada. February.

RIVM. 1994. *Intervention Values and Target Values: Soil Quality Standards. Circular on Intervention Values for Soil Remediation*. Circular from the Minister, Housing, Spatial Planning and Environment, Directorate-General for Environmental Protection, Department of Soil Protection. Ref. DBO/07494013. 9 May.

RIVM. 1995. *Risk Assessment to Man and the Environment in Case of Soil Contamination: Integration of Different Aspects*. Report No. 7235201013. National Institute of Public Health and Environmental Protection. The Netherlands.

RIVM. 1997. *Maximum Permissible Concentrations and Negligible Concentrations for Metals, Taking Background Concentrations into Account*. T. Crommentuijn, M.D. Polder, and E.J. van de Plassche. National Institute of Public Health and Environmental Protection. The Netherlands.

RIVM. 2000. *Circular on Target Values and Intervention Values for Soil Remediation*. National Institute of Public Health and Environmental Protection. The Netherlands.

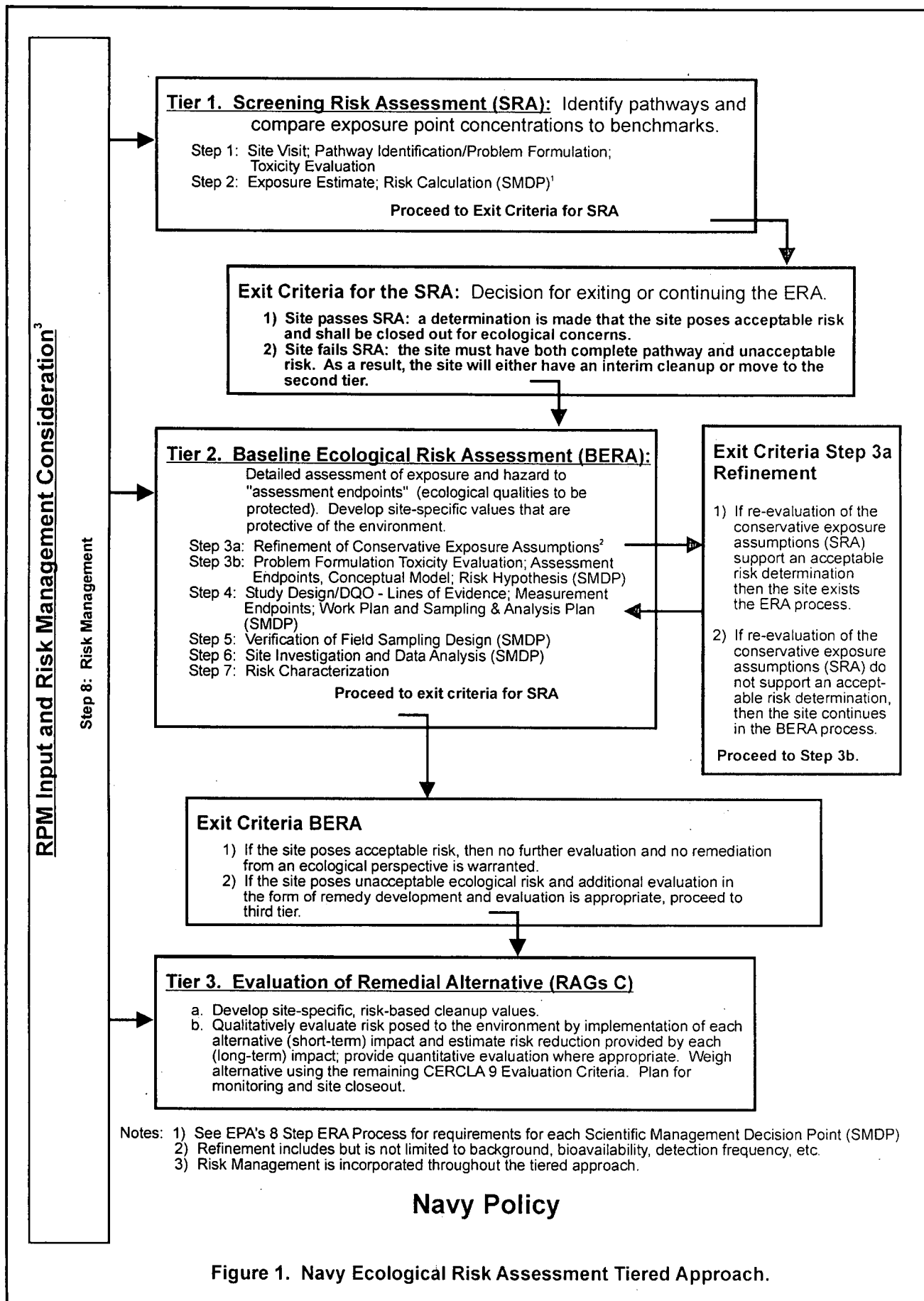
Sample, B.E., J.J. Beauchamp, R.A. Efroymsen, G.W. Suter II, and T.L. Ashwood. 1998a. *Development and Validation of Bioaccumulation Models for Earthworms*. Lockheed Martin Energy Systems, Inc., Oak Ridge National Laboratory. Rept. No. ES/ER/TM-220.

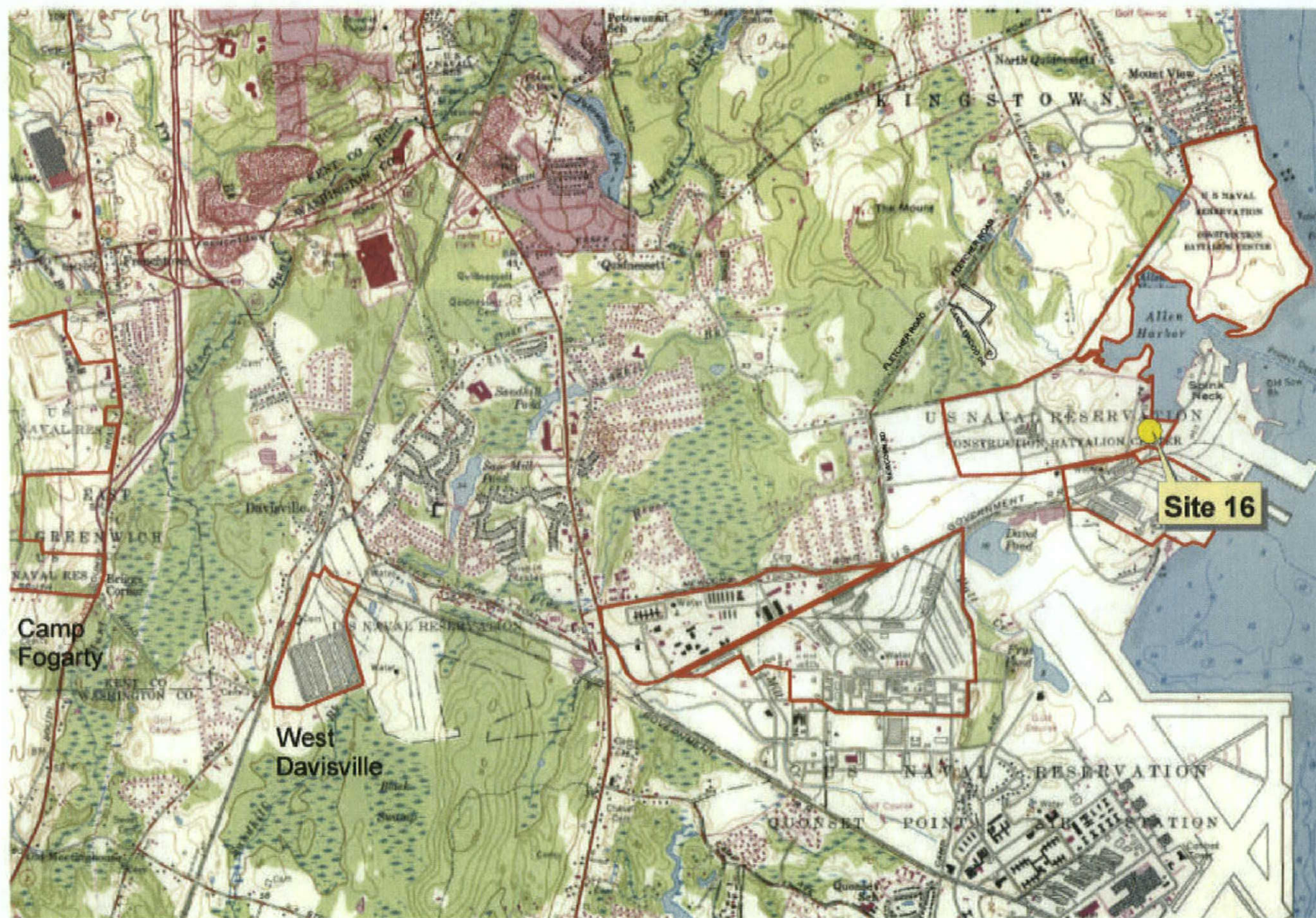
Sample, B.E., J.J. Beauchamp, R.A. Efroymsen, G.W. Suter II. 1998b. *Development and Validation of Bioaccumulation Models for Small Mammals*. Lockheed Martin Energy Systems, Inc., Oak Ridge National Laboratory. Rept. No. ES/ER/TM-219.

Sample, B.E., D.M. Opresko, and G.W. Suter II. 1996. *Toxicological Benchmarks for Wildlife: 1996 Revision*. Prepared by: The Risk Assessment Program, Health Sciences Research Division, Oak Ridge, TN. Prepared for: The U.S. Department of Energy, Office of Environmental Management. Report ES/ERTM-86/R3.

Sample, B.E. and G.W. Suter. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants*. Prepared by: Environmental Sciences Division, Oakridge National Laboratory, Oakridge, Tennessee. Prepared for: U.S. Department of Energy, Office of Environmental Restoration and Waste Management.

- Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. *Environmental Toxicology and Chemistry* 15(7):1232-1241.
- Travis, C.C. and A.D. Arms. 1988. Bioconcentration of organics in beef, milk, and vegetation. *Environmental Science and Technology* 22(3):271-274.
- U.S. Department of the Navy. 1999. *Navy Policy for Conducting Ecological Risk Assessments*. Chief of Naval Operations (CNO) Letter 5090 Ser N453E/9U595355 dated April 5.
- U.S. Environmental Protection Agency (U.S. EPA). 1977. *Guidelines for the Pollutational Classification of Great Lakes Harbor Sediments*. U.S. EPA Region 5, Chicago, Illinois.
- U.S. Environmental Protection Agency (U.S. EPA). 1993. *Wildlife Exposure Factors Handbook. Volume I of II*. U.S. EPA, Office of Research and Development, Washington, D.C. Report No. EPA/600/R-93/187a. December.
- U.S. Environmental Protection Agency (U.S. EPA). 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final*. U.S. EPA, Solid Waste and Emergency Response, Report No. EPA 540-R-97-006. June.
- U.S. Environmental Protection Agency (U.S. EPA). 1999. National Recommended Water Quality Criteria-Correction. Office of Water. EPA 822-Z-99-001. April 1999.
- U.S. Environmental Protection Agency (U.S. EPA). 2000. *Ecological Soil Screening Level Guidance*. U.S. EPA Eco-SSL Draft guidance. Washington, DC.





Approximate Scale 1" = 3000 ft.

FIGURE 2
SITE LOCUS MAP - NCBC DAVISVILLE, RI

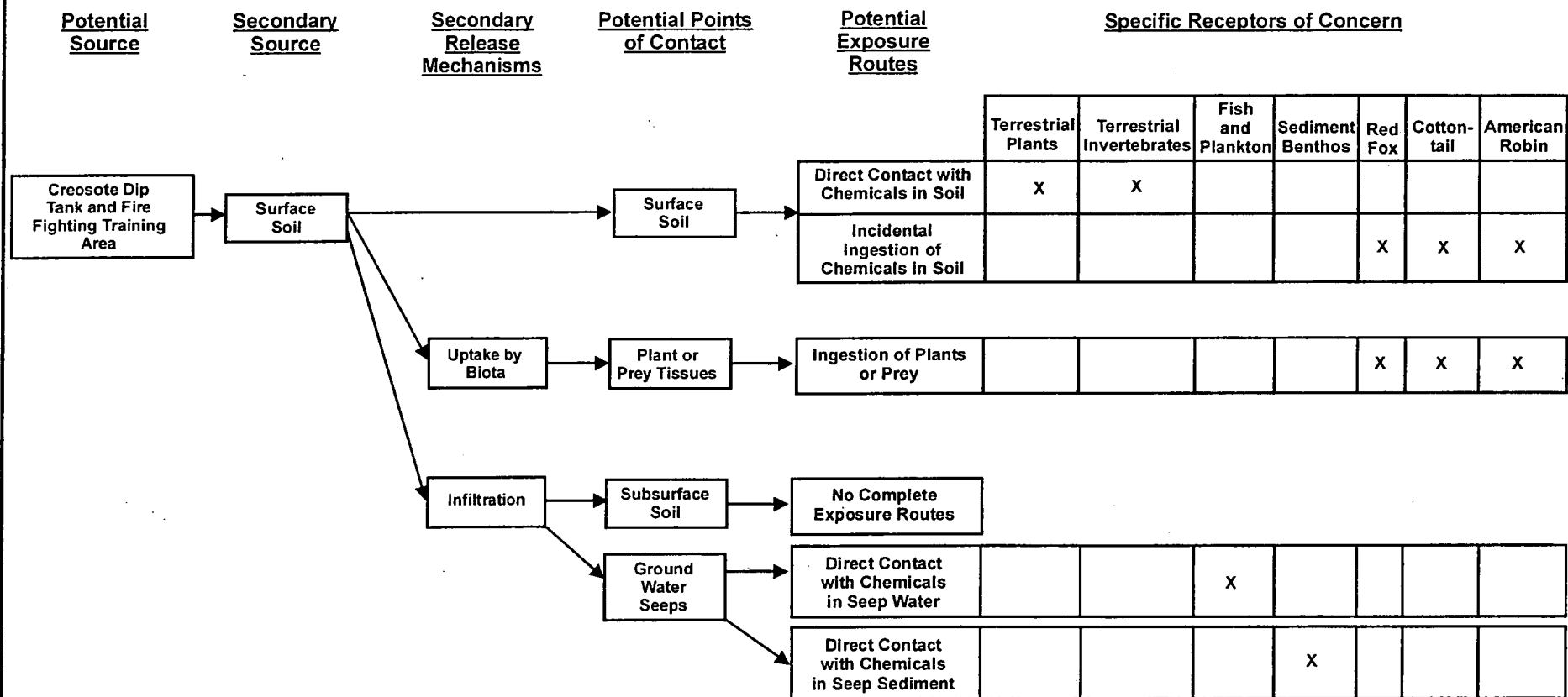


Figure 4. Ecological Risk Conceptual Site Model for Site 16, Naval Construction Battalion Center.

TABLE 1 ASSESSMENT ENDPOINTS FOR ECOLOGICAL RISK SCREENING AND FOOD WEB MODELING

Assessment Endpoint	Null Hypothesis	Measurement Endpoint	Specifics of Assessment
Ecological health of terrestrial invertebrate and plant communities	Soils are not exhibiting a detrimental effect on invertebrate or plant survival and growth	<ul style="list-style-type: none"> Evaluation of soil chemistry with respect to screening values 	<ul style="list-style-type: none"> Comparison of soil concentrations to screening values
Ecological health of marine fish and plankton communities	Seep water is not exhibiting a detrimental effect on survival, growth, or reproduction of fish and plankton	<ul style="list-style-type: none"> Evaluation of seep water chemistry with respect to screening values 	<ul style="list-style-type: none"> Comparison of seep water concentrations to screening values
Ecological health of marine benthic organisms	Seep sediments are not exhibiting a detrimental effect on benthic organisms	<ul style="list-style-type: none"> Evaluation of sediment chemistry with respect to NOAA screening values 	<ul style="list-style-type: none"> Comparison of sediment concentrations to NOAA ERLs or other appropriate benchmarks
Long-term health and reproductive capacity of omnivorous avian species (American robin)	Ingestion of COPC in prey does not have a negative impact on growth, survival, and reproductive success of the species	<ul style="list-style-type: none"> Evaluation of dose in prey based on surface soils data and dietary exposure models 	<ul style="list-style-type: none"> The risk associated with the calculated dose will be evaluated by comparison to TRV
Long-term health and reproductive Capacity of herbivorous mammalian species (Eastern cottontail)	Ingestion of COPC in food does not have a negative impact on growth, survival, and reproductive success of the species	<ul style="list-style-type: none"> Evaluation of dose in prey based on surface soils data and dietary exposure models 	<ul style="list-style-type: none"> The risk associated with the calculated dose will be evaluated by comparison to TRVs
Long-term health and reproductive capacity of primarily carnivorous mammalian species (red fox)	Ingestion of COPC in prey does not have a negative impact on growth, survival, and reproductive success of the species	<ul style="list-style-type: none"> Evaluation of dose in prey based surface soil data and dietary exposure models 	<ul style="list-style-type: none"> The risk associated with the calculated dose will be evaluated by comparison to TRVs
NOTE: COPC = Constituents of Potential Concern. ERL = Effects Range Low. NOAA = National Oceanic and Atmospheric Administration. TRVs = Toxicity Reference Values.			

TABLE 2 SOURCES OF SCREENING BENCHMARKS USED FOR SITE 16,
NCBC DAVISVILLE

Analyte	Matrix	Benchmark (ppm)	Source of Screening Criteria
INORGANICS			
Aluminum	Surface Soil	NA ¹	U.S.EPA (2000)
Arsenic	Surface Soil	10	Efroymson et al. (1997a)
Barium	Surface Soil	500	Efroymson et al. (1997a)
Beryllium	Surface Soil	10	Efroymson et al. (1997a)
Cadmium	Surface Soil	1.6	RIVM 1997
Chromium	Surface Soil	10	Efroymson et al. (1997b)
Cobalt	Surface Soil	20	Efroymson et al. (1997a)
Copper	Surface Soil	40	RIVM (1997)
Lead	Surface Soil	50	Efroymson et al. (1997a)
Manganese	Surface Soil	500	Efroymson et al. (1997a)
Mercury	Surface Soil	2.2	RIVM (1997)
Nickel	Surface Soil	90	Efroymson et al. (1997b)
Selenium	Surface Soil	1	Efroymson et al. (1997a)
Silver	Surface Soil	50	Efroymson et al. (1997b)
Thallium	Surface Soil	1	Efroymson et al. (1997a)
Vanadium	Surface Soil	20	Efroymson et al. (1997b)
Zinc	Surface Soil	50	Efroymson et al. (1997a)
PAH			
Acenaphthene	Surface Soil	20	Efroymson et al. (1997a)
Acenaphthylene	Surface Soil	1	Quebec MOE (1988)
Anthracene	Surface Soil	10	Quebec MOE (1988)
Benzo(A)anthracene	Surface Soil	1	Quebec MOE (1988)
Benzo(A)pyrene	Surface Soil	1	Quebec MOE (1988)
Benzo(B)fluoranthene	Surface Soil	1	Quebec MOE (1988)
Benzo(G,H,I)perylene	Surface Soil	1	Quebec MOE (1988)
Benzo(K)fluoranthene	Surface Soil	1	Quebec MOE (1988)
Chrysene	Surface Soil	1	Quebec MOE (1988)
Dibenz(A,H)anthracene	Surface Soil	1	Quebec MOE (1988)
Fluoranthene	Surface Soil	1	Netherlands (in: Beyer 1990)
Fluorene	Surface Soil	30	Efroymson et al. (1997b)
Indeno(1,2,3-Cd)pyrene	Surface Soil	1	Quebec MOE (1988)
Naphthalene	Surface Soil	5	Quebec MOE (1988)
Phenanthrene	Surface Soil	5	Quebec MOE (1988)
Pyrene	Surface Soil	10	Quebec MOE (1988)
Pesticide/PCB			
4,4'-Ddt	Surface Soil	2	RIVM (1995)
Alpha-BHC	Surface Soil	0.5	Netherlands (in: Beyer 1990)
Alpha-chlordane	Surface Soil	0.5	Netherlands (in: Beyer 1990)
Aroclor-1260	Surface Soil	40	Efroymson et al. (1997a) applies to Total PCB
Gamma-Chlordane	Surface Soil	0.5	Netherlands (in: Beyer 1990)

Analyte	Matrix	Benchmark (ppm)	Source of Screening Criteria
DIOXIN/FURAN			
All Compounds	Surface Soil	No data	
SVOC			
2-Methylnaphthalene	Surface Soil	5	Based on naphthalene as a surrogate
Bis(2-Ethylhexyl)phthalate	Surface Soil	30.05	RIVM 1994, 2000
Carbazole	Surface Soil	No data	
Dibenzofuran	Surface Soil	No data	
Di-n-butyl phthalate	Surface Soil	200,000	Efroymson et al. (1997a)
VOC			
2-Butanone	Surface Soil	No data	
Acetone	Surface Soil	No data	
Methylene Chloride	Surface Soil	No data	
Toluene	Surface Soil	200	Efroymson et al. (1997a)
INORGANICS			
Barium	Seep Water	0.0038	Suter (1996)
Cobalt	Seep Water	0.00306	Suter (1996)
Manganese	Seep Water	0.0803	Suter (1996)
Mercury	Seep Water	0.00094	U.S. EPA (1999) marine chronic AWQC
Nickel	Seep Water	0.0082	U.S. EPA (1999) marine chronic AWQC
PAH			
Acenaphthene	Seep Water	710	Buchman (1999)
Acenaphthylene	Seep Water	0.03	Buchman (1999) marine acute value/10
Anthracene	Seep Water	0.03	Buchman (1999) marine acute value/10
Fluoranthene	Seep Water	0.016	Buchman (1999)
Fluorene	Seep Water	0.03	Buchman (1999) marine acute value/10
Naphthalene	Seep Water	235	Buchman (1999) marine acute value/10
Phenanthrene	Seep Water	0.0046	Buchman (1999)
Pyrene	Seep Water	0.03	Buchman (1999) marine acute value/10
PESTICIDE/PCB			
Alpha-Bhc	Seep Water	0.00244	Suter (1996)
Dieldrin	Seep Water	0.0000019	U.S. EPA (1999) marine chronic AWQC
Endrin	Seep Water	0.0000023	U.S. EPA (1999) marine chronic AWQC
Heptachlor Epoxide	Seep Water	0.0000036	U.S. EPA (1999) marine chronic AWQC

Analyte	Matrix	Benchmark (ppm)	Source of Screening Criteria
SVOC			
2-Methylnaphthalene	Seep Water	30	Buchman (1999) marine acute value/10
Dibenzofuran	Seep Water	0.0204	Suter (1996)
VOC			
1,2-Dichloroethene	Seep Water	22.4	Buchman (1999) marine acute value/10
Trichloroethene	Seep Water	0.2	Buchman (1999) marine acute value/10
Vinyl Chloride	Seep Water	0.0878	Suter (1996)
INORGANICS			
Aluminum	Sediment	18,000	Buchman (1999)
Antimony	Sediment	2	Long and Morgan (1990) (ERL)
Arsenic	Sediment	8.2	Long et al. (1995) (ERL)
Barium	Sediment	20	U.S. EPA (1977)
Beryllium	Sediment	10	Based on soil value
Cadmium	Sediment	1.2	Long et al. (1995) (ERL)
Chromium	Sediment	81	Long et al. (1995) (ERL)
Cobalt	Sediment	No data	
Copper	Sediment	34	Long et al. (1995) (ERL)
Lead	Sediment	46.7	Long et al. (1995) (ERL)
Manganese	Sediment	260	Buchman (1999)
Mercury	Sediment	0.15	Long et al. (1995) (ERL)
Nickel	Sediment	20.9	Long et al. (1995) (ERL)
Selenium	Sediment	1	New Jersey DEP (1987)
Vanadium	Sediment	No data	
Zinc	Sediment	150	Long et al. (1995) (ERL)
PAH			
Acenaphthene	Sediment	0.016	Long et al. (1995) (ERL)
Acenaphthylene	Sediment	0.044	Long et al. (1995) (ERL)
Benzo(A)anthracene	Sediment	0.261	Long et al. (1995) (ERL)
Benzo(A)pyrene	Sediment	0.43	Long et al. (1995) (ERL)
Benzo(B)fluoranthene	Sediment	no data	
Benzo(G,H,I)perylene	Sediment	0.17	Persaud et al. (1993)
Benzo(K)fluoranthene	Sediment	0.24	Persaud et al. (1993)
Chrysene	Sediment	0.384	Long et al. (1995) (ERL)
Fluoranthene	Sediment	0.6	Long et al. (1995) (ERL)
Fluorene	Sediment	0.019	Long et al. (1995) (ERL)
Indeno(1,2,3-Cd)pyrene	Sediment	0.2	Persaud et al. (1993)
Phenanthrene	Sediment	0.24	Long et al. (1995) (ERL)
Pyrene	Sediment	0.665	Long et al. (1995) (ERL)
PESTICIDE/PCB			
4,4'-DDD	Sediment	0.002	Long and Morgan (1990) (ERL)
4,4'-DDE	Sediment	0.0022	Long et al. (1995) (ERL)
4,4'-DDT	Sediment	0.001	Long and Morgan (1990) (ERL)
Aroclor-1260	Sediment	0.0227	Long and Morgan (1990) (ERL)
Delta-BHC	Sediment	0.003	Persaud et al. (1993)

Analyte	Matrix	Benchmark (ppm)	Source of Screening Criteria
Dieldrin	Sediment	0.00002	Long and Morgan (1990) (ERL)
Endosulfan Sulfate	Sediment	0.005481	Based on endosulfan
Endrin Ketone	Sediment	0.00002	Based on endrin ERL
<i>Gamma</i> -Chlordane	Sediment	0.0005	Long and Morgan (1990) (ERL)
Heptachlor	Sediment	0.0005	Buchman (1999) Based on chlordane ERL
Heptachlor Epoxide	Sediment	0.0005	Buchman (1999) Based on chlordane ERL
SVOC			
Bis(2-Ethylhexyl)Phthalate	Sediment	890	Jones et al. (1997)
Carbon Disulfide	Sediment	30	Partition: K _{oc} =89; f _{oc} =.05; water critical=135 ppm divided by 20
Dibenzofuran	Sediment	0.42	Jones et al. (1997)
Di-n-Octyl Phthalate	Sediment	11	Jones et al. (1997) (di-n-butyl phthalate as surrogate)
VOC			
Acetone	Sediment	0.0087	Jones et al. (1997)
<p>¹ Aluminum not screened in surface soil because all soil pH measurements were 5.5 or greater, following U.S.EPA (2000).</p> <p>NOTE: AWQC = Ambient water quality criteria. ERL = Effects Range Low NCBC = Naval Construction Battalion Center PAH = Polycyclic aromatic hydrocarbons. PCB = Polychlorinated biphenyls. Ppm = Parts per million. SVOC = Semivolatile organic compounds. U.S. EPA = U.S. Environmental Protection Agency VOC = Volatile organic compounds.</p>			

TABLE 3 SITE 16 SURFACE SOIL COPC SCREEN

Analyte	Units	Minimum Concentration	Maximum Concentration	Maximum Location	Detection Frequency	Screening Value ¹	HQ	COPC
INORGANICS								
Aluminum	mg/kg	2,570	8,590	SB16-28-0-2	9/9	NA ²	NA ²	
Arsenic	mg/kg	ND	4	SB16-28-0-2	7/9	10	0.4	
Barium	mg/kg	14.8	40.6	SB16-26-0-2	9/9	500	0.1	
Beryllium	mg/kg	0.33	0.64	SB16-28-0-2	9/9	10	0.1	
Cadmium	mg/kg	ND	0.56	SB16-24-0-2	2/9	1.6	0.4	
Calcium	mg/kg	ND	1,200	SB16-23-0-2	8/9	EN	EN	
Chromium	mg/kg	2.9	11.6	SB16-28-0-2	9/9	10	1.2	YES
Cobalt	mg/kg	2	7.8	SB16-28-0-2	9/9	20	0.4	
Copper	mg/kg	8.2	40.2	SB16-23-0-2	9/9	40	1.0	
Iron	mg/kg	5,930	21,200	SB16-28-0-2	9/9	EN	EN	
Lead	mg/kg	13.45	98.4	SB16-24-0-2	9/9	50	2.0	YES
Magnesium	mg/kg	540	2,140	SB16-28-0-2	9/9	EN		
Manganese	mg/kg	84.4	248	SB16-28-0-2	9/9	500	0.5	
Mercury	mg/kg	ND	0.11	SB16-25-0-2	1/9	2.2	0.1	
Nickel	mg/kg	ND	11	SB16-28-0-2	6/9	90	0.1	
Potassium	mg/kg	ND	685	SB16-21-0-2	8/9	EN	EN	
Selenium	mg/kg	ND	0.88	SB16-28-0-2	1/9	1	0.9	
Silver	mg/kg	ND	0.32	SB16-25-0-2	1/9	50	0.0	
Sodium	mg/kg	ND	82	SB16-23-0-2	5/9	EN	EN	
Thallium	mg/kg	ND	0.65	SB16-27-0-2	1/9	1	0.7	
Vanadium	mg/kg	4.7	16.1	SB16-28-0-2	9/9	20	0.8	
Zinc	mg/kg	29.8	85.3	SB16-28-0-2	9/9	50	1.7	YES
PAH								
Acenaphthene	µg/kg	ND	2,400	28-SB-01B	6/29	20,000	0.1	
Acenaphthylene	µg/kg	ND	770	SB16-21-0-2	4/29	1,000	0.8	
Anthracene	µg/kg	ND	4,600	28-SB-01B	11/29	10,000	0.5	
Benzo(A)Anthracene	µg/kg	ND	4,450	SB16-21-0-2	18/29	1,000	4.5	YES

Analyte	Units	Minimum Concentration	Maximum Concentration	Maximum Location	Detection Frequency	Screening Value ¹	HQ	COPC
Benzo(A)Pyrene	µg/kg	ND	2,350	SB16-21-0-2	19/29	1,000	2.4	YES
Benzo(B)Fluoranthene	µg/kg	ND	7,400	SB16-21-0-2	21/29	1,000	7.4	YES
Benzo[G,H,I]Perylene	µg/kg	ND	1,050	SB16-21-0-2	17/29	1,000	1.1	YES
Benzo(K)Fluoranthene	µg/kg	ND	1,800	SB16-21-0-2	15/29	1,000	1.8	YES
Chrysene	µg/kg	ND	4,750	SB16-21-0-2	21/29	1,000	4.8	YES
Dibenzo(A,H)Anthracene	µg/kg	ND	750	SB16-21-0-2	10/29	1,000	0.8	
Fluoranthene	µg/kg	ND	4,305	SB16-21-0-2	20/29	1,000	4.3	YES
Fluorene	µg/kg	ND	592.5	SB16-21-0-2	6/29	30,000	0.0	
Indeno(1,2,3-Cd)Pyrene	µg/kg	ND	2,300	SB16-21-0-2	17/29	1,000	2.3	YES
Naphthalene	µg/kg	ND	557	SB16-21-0-2	3/29	5,000	0.1	
Phenanthrene	µg/kg	ND	920	SB16-28-0-2	17/29	5,000	0.2	
Pyrene	µg/kg	ND	6,400	SB16-21-0-2	21/29	10,000	0.6	
PESTICIDE/PCB								
4,4'-DDT	µg/kg	ND	3.7	SB16-26-0-2	1/8	2,000	0.0	
Alpha BHC	µg/kg	ND	2.4	SB16-28-0-2	1/8	500	0.0	
Gamma-Chlordane	µg/kg	ND	2.9	SB16-21-0-2	1/9	500	0.0	
Pcb-1260	µg/kg	ND	14	SB16-21-0-2	1/9	40,000	0.0	
DIOXIN/FURAN								
Dioxin Toxicity Equivalent ³	ppt	2.60	45.21	SB16-25-0-2	8/8	NSV	NSV	
SVOC								
2-Methylnaphthalene	µg/kg	ND	558	SB16-21-0-2	2/25	5,000	0.1	
Bis(2-Ethylhexyl) Phthalate	µg/kg	ND	106	EBS-28-SB08-0-2	2/25	30,050	0.0	
Carbazole	µg/kg	ND	405	SB16-21-0-2	2/25	NSV	NSV	
Di-N-Butyl Phthalate	µg/kg	ND	56	EBS-28-SB05-0-2	6/25	200,000	0.0	
VOC								
2-Butanone	µg/kg	ND	12	SB16-27-0-2	3/26	NSV	NSV	
Acetone	µg/kg	ND	3,700	EBS-28-SB04-0-2	14/26	NSV	NSV	
Methylene Chloride	µg/kg	ND	4.5	EBS-28-SB07-0-2	3/26	NSV	NSV	
Toluene	µg/kg	ND	6	EBS-28-SB15-0-2	1/26	200,000	0.0	

Analyte	Units	Minimum Concentration	Maximum Concentration	Maximum Location	Detection Frequency	Screening Value ¹	HQ	COPC
¹ From Table 2 ² Aluminum not screened in surface soil because all soil pH measurements were 5.5 or greater, following EPA (2000) ³ Based on World Health Organization (WHO) Toxic Equivalency Factors for mammals. NOTE: COPC = Constituent of Potential Concern. EN = Essential nutrient (not screened). HQ = Hazard Quotient. mg/kg = Micrograms per kilogram. ND = Not detected. NSV = No screening value. PAH = Polycyclic aromatic hydrocarbons. PCB = Polychlorinated biphenyls. ppt = Parts per thousand. SVOC = Semivolatile organic compounds. µg/kg = Micrograms per kilogram. VOC = Volatile organic compounds.								

TABLE 4 SITE 16 SEEP WATER COPC SCREEN

Analyte	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Maximum Location	Detection Frequency	Screening Value (µg/L) ¹	HQ	COPC
METALS							
Barium	1.8	271.5	SEEP16-01	2/2	3.8	71.4	YES
Calcium	25,700	47,950	SEEP16-01	2/2	EN	EN	
Cobalt	ND	9	SEEP16-02	1/2	3.06	2.9	YES
Iron	5,100	20,700	SEEP16-01	2/2	EN	EN	
Magnesium	4,820	26,200	SEEP16-02	2/2	EN	EN	
Manganese	445	2,040	SEEP16-02	2/2	80.3	25.4	YES
Mercury	ND	0.07	SEEP16-02	1/2	0.94	0.1	
Nickel	ND	2.1	SEEP16-02	1/2	8.2	0.3	
Potassium	3,575	10,500	SEEP16-02	2/2	EN	EN	
Sodium	13,300	176,000	SEEP16-02	2/2	EN	EN	
PAH							
Acenaphthene	ND	35.5	SEEP16-01	2/3	710	0.1	
Acenaphthylene	ND	0.2	SEEP16-01	1/3	30	0.0	
Anthracene	ND	1.5	SEEP16-01	1/3	30	0.1	
Fluoranthene	ND	4	28-SP-01	2/3	16	0.3	
Fluorene	ND	14.5	SEEP16-01	2/3	30	0.5	
Naphthalene	ND	4	SEEP16-01	2/3	235	0.0	
Phenanthrene	ND	7	28-SP-01	2/3	4.6	1.5	YES
Pyrene	ND	2	28-SP-01	2/3	30	0.1	
PESTICIDE/PCB							
Alpha Bhc	ND	0.0325	SEEP16-01	1/3	2.44	0.0	
Dieldrin	ND	0.02	28-SP-01	1/3	0.0019	10.5	YES
Endrin	ND	0.0039	28-SP-01	1/3	0.0023	1.7	YES
Heptachlor Epoxide	ND	0.02	28-SP-01	1/3	0.0036	5.6	YES

Analyte	Minimum Concentration (µg/L)	Maximum Concentration (µg/L)	Maximum Location	Detection Frequency	Screening Value (µg/L) ¹	HQ	COPC
SVOC							
2-Methylnaphthalene	ND	0.95	SEEP16-01	1/3	30,000	0.0	
Dibenzofuran	8	11.5	SEEP16-01	2/2	20.4	0.6	
VOC							
Cis-1,2-Dichloroethene	ND	0.7	SEEP16-02	1/2	22,400	0.0	
Total 1,2-Dichloroethene	ND	0.7	SEEP16-02	1/3	22,400	0.0	
Trichloroethene	ND	0.7	SEEP16-02	1/3	200	0.0	
Vinyl Chloride	ND	0.45	SEEP16-01	1/3	87.8	0.0	
<p>¹From Table 2.</p> <p>NOTE: COPC = Constituent of Potential Concern. EN = Essential nutrient (not screened). HQ = Hazard Quotient. ND = Not detected. PAH = Polycyclic aromatic hydrocarbons. PCB = Polychlorinated biphenyls. SVOC = Semivolatile organic compounds. µg/L = Micrograms per Liter. VOC = Volatile organic compounds.</p>							

TABLE 5 SITE 16 SEDIMENT COPC SCREEN

Analyte	Units	Minimum Concentration	Maximum Concentration	Maximum Location	Detection Frequency	Screening Value ¹	HQ	COPC
METALS								
Aluminum	mg/kg	2,370	5,670	SED16-02	3/3	18,000	0.3	
Antimony	mg/kg	0.5	1.35	SED16-01	3/3	2	0.7	
Arsenic	mg/kg	0.97	36.6	SED16-02	3/3	8.2	4.5	YES
Barium	mg/kg	23.5	110.1	SED16-01	3/3	20	5.5	YES
Beryllium	mg/kg	0.32	0.905	SED16-01	3/3	10	0.1	
Cadmium	mg/kg	ND	0.19	SED16-02	1/3	1.2	0.2	
Calcium	mg/kg	1,380	1,815	SED16-01	3/3	EN	EN	
Chromium	mg/kg	11.7	33.5	OPSED16-01	3/3	81	0.4	
Cobalt	mg/kg	2.4	37.9	SED16-02	3/3	NSV	NSV	
Copper	mg/kg	13.4	127	SED16-01	3/3	34	3.7	YES
Iron	mg/kg	6,400	63,350	SED16-01	3/3	EN	EN	
Lead	mg/kg	11.4	154	OPSED16-01	3/3	46.7	3.3	YES
Magnesium	mg/kg	994	2,020	SED16-02	3/3	EN	EN	
Manganese	mg/kg	89	788	SED16-02	3/3	260	3.0	YES
Mercury	mg/kg	ND	0.055	SED16-01	1/3	0.15	0.4	
Nickel	mg/kg	11.5	53.8	SED16-01	3/3	20.9	2.6	YES
Potassium	mg/kg	599	916	SED16-02	3/3	EN	EN	
Selenium	mg/kg	ND	1.3	SED16-01	1/3	1	1.3	YES
Sodium	mg/kg	ND	239.5	SED16-01	1/3	EN	EN	
Vanadium	mg/kg	15.45	22.9	SED16-02	3/3	NSV	NSV	
Zinc	mg/kg	50.5	346	SED16-01	3/3	150	2.3	YES
PAH								
Acenaphthene	µg/kg	ND	905	SED16-01	1/3	16	56.6	YES
Acenaphthylene	µg/kg	ND	110	OPSED16-01	1/3	44	2.5	YES
Benzo(A)Anthracene	µg/kg	20	200	OPSED16-01	3/3	261	0.8	
Benzo(A)Pyrene	µg/kg	ND	300	OPSED16-01	1/3	430	0.7	

Analyte	Units	Minimum Concentration	Maximum Concentration	Maximum Location	Detection Frequency	Screening Value ¹	HQ	COPC
Benzo(B)Fluoranthene	µg/kg	41	480	OPSED16-01	3/3	NSV	NSV	
Benzo(K)Fluoranthene	µg/kg	ND	340	OPSED16-01	1/3	240	1.4	YES
Benzo[G,H,I]Perylene	µg/kg	ND	380	OPSED16-01	2/3	170	2.2	YES
Chrysene	µg/kg	34	450	OPSED16-01	3/3	384	1.2	YES
Fluoranthene	µg/kg	64	1,800	SED16-01	3/3	600	3.0	YES
Fluorene	µg/kg	ND	580	SED16-01	1/3	19	30.5	YES
Indeno(1,2,3-Cd)Pyrene	µg/kg	ND	250	OPSED16-01	1/3	200	1.3	YES
Phenanthrene	µg/kg	44	790	OPSED16-01	3/3	240	3.3	YES
Pyrene	µg/kg	68	855	SED16-01	3/3	665	1.3	YES
PESTICIDE/PCB								
4,4'-DDD	µg/kg	ND	3.45	SED16-01	2/3	2	1.7	YES
4,4'-DDE	µg/kg	ND	1.7	OPSED16-01	2/3	2.2	0.8	
4,4'-DDT	µg/kg	ND	1.8	SED16-02	2/3	1	1.8	YES
Delta BHC	µg/kg	ND	1.5	OPSED16-01	1/3	3	0.5	
Dieldrin	µg/kg	ND	1.7	SED16-02	1/3	0.02	85.0	YES
Endosulfan Sulfate	µg/kg	ND	2.1	SED16-01	1/3	5.481	0.4	
Endrin Ketone	µg/kg	0.64	1.6	OPSED16-01	3/3	0.02	80.0	YES
Gamma-Chlordane	µg/kg	ND	1.7	OPSED16-01	1/3	0.5	3.4	YES
Heptachlor	µg/kg	ND	0.71	SED16-02	2/3	0.5	1.4	YES
Heptachlor Epoxide	µg/kg	ND	1.2	OPSED16-01	1/3	0.5	2.4	YES
PCB-1260	µg/kg	ND	36	SED16-01	1/3	22.7	1.6	YES
SVOC								
Bis(2-Ethylhexyl) Phthalate	µg/kg	320	3,600	OPSED16-01	3/3	890,000	0.0	
Carbon Disulfide	µg/kg	ND	27.5	SED16-01	2/3	30,000	0.0	
Dibenzofuran	µg/kg	ND	255	SED16-01	1/3	420	0.6	
Di-N-Octylphthalate	µg/kg	ND	550	OPSED16-01	1/3	11,000	0.1	
VOC								
Acetone	µg/kg	57	120	SED16-02	3/3	8.7	13.8	YES

EA Engineering, Science, and Technology

Analyte	Units	Minimum Concentration	Maximum Concentration	Maximum Location	Detection Frequency	Screening Value ¹	HQ	COPC
<p>From Table 2.</p> <p>NOTE: COPC = Constituent of Potential Concern. EN = Essential nutrient (not screened). HQ = Hazard Quotient. mg/kg = Milligrams per kilogram. ND = Not detected. NSV = No screening value. PAH = Polycyclic aromatic hydrocarbons. µg/kg = Micrograms per kilogram.</p>								

TABLE 6 FOOD-WEB EXPOSURE FACTORS FOR ECOLOGICAL RECEPTORS OF CONCERN

Exposure Factor	American Robin	Red Fox	Eastern Cottontail
Body Weight (kg)	0.0810200 (U.S. EPA 1993)	5.0 (U.S. EPA 1993)	1.134 (Sample and Suter 1994)
Food Ingestion Rate (kg/day)	0.0976300 (U.S. EPA 1993)	0.320 (U.S. EPA 1993)	0.237 (Sample and Suter 1994)
Soil Ingestion Rate (kg/day)	0.0292890 (Based on 10% of food ingestion rate, U.S. EPA 1993)	0.0090 (Based on 3% of food ingestion rate, U.S. EPA 1993)	0.015 (Based on 6.3% of food ingestion rate, Sample and Suter 1994)
Habitat Ratio (relative to site size of 4.5 Ha)	1.0 (Based on habitat range of 0.4 Ha, U.S. EPA 1993)	1.0 for conservative food web and 0.006 for refined food web (Based on a habitat range of 750 Ha, U.S. EPA 1993)	1.0 (Based on habitat range of 4.0 Ha, U.S. EPA 1993)
NOTE: kg = Kilogram. Ha = Health advisory.			

**TABLE 7 LIST OF TOXICITY REFERENCE VALUES FOR USE IN
FOOD-WEB MODELING**

Analyte	Eastern Cottontail mg/kg-bw/day	Red fox mg/kg-bw/day	American robin mg/kg-bw/day
INORGANICS			
Chromium	1445.0	1445.0	1.0
Lead	4.22	4.22	3.85
Zinc	84.5	84.5	14.5
PAH			
Benzo(a)pyrene*	0.29	0.29	--
SVOC			
2-Butanone	935	935	--
Carbazole	--	--	--
DIOXIN/FURAN			
2,3,7,8-TCDD	0.0000005	0.0000005	0.000014
VOC			
Acetone	5.3	5.3	--
Methylene chloride	3.1	3.1	--
<p>NOTE: TRVs accessed from U.S. Navy, Naval Facilities Engineering Command, Northern Division Benchmark Screening Values Database (based on Sample et al. [1996]).</p> <p>Eastern cottontail and red fox TRVs are identical because both are classified as "medium mammals" in the Navy Benchmark Screening Values Database.</p> <p>TRV available only for benzo(a)pyrene; this value used for all PAH COPC.</p> <p>-- = Dashed line indicates no TRV available. COPC = Constituents of Potential Concern. Mg/kg = Milligram per kilogram. PAH = Polycyclic aromatic hydrocarbons. SVOC = Semivolatile organic compounds. TRV = Toxicity Reference Value. VOC = Volatile organic compounds.</p>			

**TABLE 8 CONSERVATIVE FOOD-WEB RESULTS FOR THE EASTERN COTTONTAIL
NCBC DAVISVILLE SITE 16**

Ecological Contaminant of Concern	Soil Concentration (mg/kg)	Food Concentration (mg/kg)	Dose (mg/kg/day)	TRV (mg/kg/day)	HQ	HQ>1?
Chromium	11.6	11.6	2.578	1,445	0.0	
Lead	98.4	98.4	21.867	4.22	5.2	YES
Zinc	85.3	85.3	18.956	84.5	0.2	
Benzo(a)anthracene	4.45	4.45	0.989	0.29	3.4	YES
Benzo(a)pyrene	2.35	2.35	0.522	0.29	1.8	YES
Benzo(b)fluoranthene	7.4	7.4	1.644	0.29	5.7	YES
Benzo[g,h,i]perylene	1.05	1.05	0.233	0.29	0.8	
Benzo(k)fluoranthene	1.8	1.8	0.400	0.29	1.4	YES
Chrysene	4.75	4.75	1.056	0.29	3.6	YES
Fluoranthene	4.305	4.035	0.900	0.29	3.1	YES
Indeno(1,2,3-cd)pyrene	2.3	2.3	0.511	0.29	1.8	YES
Dioxin Toxicity Equivalent	0.00004521	0.00004521	0.000	0.0000005	20.1	YES
Carbazole	0.405	0.405	0.090	No TRV	No TRV	
2-Butanone	0.012	0.012	0.003	1301	0.0	
Acetone	3.7	3.7	0.822	7.3	0.1	
Methylene chloride	0.0045	0.0045	0.001	4.3	0.0	
NOTE: HQ = Hazard Quotient. mg/kg = Milligrams per kilogram. NCBC = Naval Construction Battalion Center. TRV = Toxicity Reference Value.						

**TABLE 9 CONSERVATIVE FOOD-WEB RESULTS FOR THE RED FOX
NCBC DAVISVILLE SITE 16**

Ecological Contaminant of Concern	Soil Concentration (mg/kg)	Food Concentration (mg/kg)	Dose (mg/kg/day)	TRV (mg/kg/day)	HQ	HQ>1?
Chromium	11.6	11.6	0.763	1445	0.0	
Lead	98.4	98.4	6.475	4.22	1.5	YES
Zinc	85.3	85.3	5.613	84.5	0.1	
Benzo(a)anthracene	4.45	4.45	0.293	0.29	1.0	YES
Benzo(a)pyrene	2.35	2.35	0.155	0.29	0.5	
Benzo(b)fluoranthene	7.4	7.4	0.487	0.29	1.7	YES
Benzo[g,h,i]perylene	1.05	1.05	0.069	0.29	0.2	
Benzo(k)fluoranthene	1.8	1.8	0.118	0.29	0.4	
Chrysene	4.75	4.75	0.313	0.29	1.1	YES
Fluoranthene	4.305	4.035	0.266	0.29	0.9	
Indeno(1,2,3-cd)pyrene	2.3	2.3	0.151	0.29	0.5	
Dioxin Toxicity Equivalent	0.00004521	0.00004521	0.000	0.0000005	5.9	YES
Carbazole	0.405	0.405	0.027	No TRV	No TRV	
2-Butanone	0.012	0.012	0.001	935	0.0	
Acetone	3.7	3.7	0.243	5.3	0.0	
Methylene chloride	0.0045	0.0045	0.000	3.1	0.0	
NOTE: HQ = Hazard Quotient. mg/kg = Milligram per kilogram. NCBC = Naval Construction Battalion Center. TRV = Toxicity Reference Value.						

**TABLE 10 CONSERVATIVE FOOD-WEB RESULTS FOR THE AMERICAN ROBIN
NCBC DAVISVILLE SITE 16**

Ecological Contaminant of Concern	Soil Concentration (mg/kg)	Food Concentration (mg/kg)	Dose (mg/kg/day)	TRV (mg/kg/day)	HQ	HQ>1?
Chromium	11.6	11.6	15.376	1	15.4	YES
Lead	98.4	98.4	130.430	3.85	33.9	YES
Zinc	85.3	85.3	113.066	14.5	7.8	YES
Benzo(a)anthracene	4.45	4.45	5.899	NoTRV	NoTRV	
Benzo(a)pyrene	2.35	2.35	3.115	NoTRV	NoTRV	
Benzo(b)fluoranthene	7.4	7.4	9.809	NoTRV	NoTRV	
Benzo[g,h,i]perylene	1.05	1.05	1.392	NoTRV	NoTRV	
Benzo(k)fluoranthene	1.8	1.8	2.386	NoTRV	NoTRV	
Chrysene	4.75	4.75	6.296	NoTRV	NoTRV	
Fluoranthene	4.305	4.035	5.381	NoTRV	NoTRV	
Indeno(1,2,3-cd)pyrene	2.3	2.3	3.049	NoTRV	NoTRV	
Dioxin Toxicity Equivalent	0.00007554	0.00007554	0.000	0.000014	7.2	YES
Carbazole	0.405	0.405	0.537	No TRV	No TRV	
2-Butanone	0.012	0.012	0.016	No TRV	No TRV	
Acetone	3.7	3.7	4.904	No TRV	No TRV	
Methylene chloride	0.0045	0.0045	0.006	No TRV	No TRV	
NOTE: HQ = Hazard Quotient. mg/kg = Milligram per kilogram. NCBC = Naval Construction Battalion Center. TRV = Toxicity Reference Value.						

TABLE 11 BIOACCUMULATION FACTORS
USED IN REFINED FOOD-WEB MODEL

Analyte	Invertebrate			Plant			Mammal		
	BAF	Type	Source	BAF	Type	Source	BAF	Type	Source
Chromium	0.50592	90th Percentile UF	(1)	1	Conservative	(2)	0.0373	General Regression	(5)
Lead	0.053	Simple Regression	(1)	0.0085	Simple Regression	(3)	0.0157	General Regression	(5)
Zinc	0.69	Simple Regression	(1)	0.16	Simple Regression	(3)	0.456	General Regression	(5)
Benz(a)anthracene	1.0	Conservative	(2)	0.017	Geometric Mean Regression	(4)	1	Conservative	(2)
Benzo(a)pyrene	1.0	Conservative	(2)	0.011	Geometric Mean Regression	(4)	1	Conservative	(2)
Benzo(b)fluoranthene	1.0	Conservative	(2)	0.009	Geometric Mean Regression	(4)	1	Conservative	(2)
Benzo(g,h,i)perylene	1.0	Conservative	(2)	0.005	Geometric Mean Regression	(4)	1	Conservative	(2)
Benzo(k)fluoranthene	1.0	Conservative	(2)	0.0008	Geometric Mean Regression	(4)	1	Conservative	(2)
Chrysene	1.0	Conservative	(2)	0.017	Geometric Mean Regression	(4)	1	Conservative	(2)
Fluoranthene	1.0	Conservative	(2)	0.042	Geometric Mean Regression	(4)	1	Conservative	(2)
Indeno(1,2,3-cd)pyrene	1.0	Conservative	(2)	0.005	Geometric Mean Regression	(4)	1	Conservative	(2)
Dioxin Toxicity Equivalent	1.0	Conservative	(2)	0.009	Geometric Mean Regression	(4)	1	Conservative	(2)
Carbazole	1.0	Conservative	(2)	1	Conservative	(2)	1	Conservative	(2)
2-Butanone	1.0	Conservative	(2)	1	Geometric Mean Regression	(2)	1	Conservative	(2)
Acetone	1.0	Conservative	(2)	1	Geometric Mean Regression	(2)	1	Conservative	(2)
Methylene chloride	1.0	Conservative	(2)	1	Conservative	(2)	1	Conservative	(2)
(1) Sample et al. 1998a. (2) default. (3) Bechtel Jacobs 1998. (4) Travis and Arms 1988. (5) Sample et al. 1998b. NOTE: BAFs are dry soil/wet tissue basis. BAFs = Bio-accumulation Factor. UF = Uptake factor.									

TABLE 12 STEP 3a REFINED FOOD-WEB RESULTS FOR THE
EASTERN COTTONTAIL, NCBC DAVISVILLE SITE 16

Ecological Contaminant of Concern	Soil Concentration (mg/kg)	Vegetation Concentration (mg/kg)	Dose (mg/kg/day)	TRV (mg/kg/day)	HQ	HQ>1?
Chromium	9.164	2.7840	0.7031	1,445	0.00	
Lead	77.736	0.8347	1.2027	4.22	0.29	
Zinc	67.387	13.6742	3.7492	84.5	0.04	
Benz(a)anthracene	3.516	0.0224	0.0512	0.29	0.18	
Benzo(a)pyrene	1.857	0.0079	0.0262	0.29	0.09	
Benzo(b)fluoranthene	5.846	0.0195	0.0814	0.29	0.28	
Benzo(g,h,i)perylene	0.830	0.0015	0.0113	0.29	0.04	
Benzo(k)fluoranthene	1.422	0.0004	0.0189	0.29	0.07	
Chrysene	3.753	0.0239	0.0546	0.29	0.19	
Fluoranthene	3.401	0.0548	0.0564	0.29	0.19	
Indeno(1,2,3-cd)pyrene	1.817	0.0033	0.0247	0.29	0.09	
Dioxin Toxicity Equivalent	3.572E-05	1.1935E-07	4.9738E-07	0.0000005	0.99	
Carbazole	0.320	0.0972	0.0245	No TRV	No TRV	
2-Butanone	0.009	0.0029	0.0007	935	0.00	
Acetone	2.923	0.8880	0.2243	5.3	0.04	
Methylene chloride	0.004	0.0011	0.0003	3.1	0.00	
NOTE: HQ = Hazard Quotient. mg/kg = Milligram per kilogram. NCBC = Naval Construction Battalion Center. TRV = Toxicity Reference Value.						

TABLE 13 STEP 3a REFINED FOOD-WEB RESULTS FOR THE RED FOX, NCBC DAVISVILLE SITE 16

Ecological Contaminant of Concern	Soil Concentration (mg/kg)	Vegetation Concentration (mg/kg)	Mammal Concentration (mg/kg)	Dose (mg/kg/day)	TRV (mg/kg/day)	HQ	HQ>1?
Chromium	9.1640	2.7840	0.4324	0.0004	1,445	0.00	
Lead	77.7360	0.8347	1.5439	0.0014	4.22	0.00	
Zinc	67.3870	13.6742	38.8611	0.0147	84.5	0.00	
Benz(a)anthracene	3.5155	0.0224	1.4240	0.0005	0.29	0.00	
Benzo(a)pyrene	1.8565	0.0079	0.7520	0.0003	0.29	0.00	
Benzo(b)fluoranthene	5.8460	0.0195	2.3680	0.0009	0.29	0.00	
Benzo(g,h,i)perylene	0.8295	0.0015	0.3360	0.0001	0.29	0.00	
Benzo(k)fluoranthene	1.4220	0.0004	0.5760	0.0002	0.29	0.00	
Chrysene	3.7525	0.0239	1.5200	0.0006	0.29	0.00	
Fluoranthene	3.4010	0.0548	1.3776	0.0005	0.29	0.00	
Indeno(1,2,3-cd)pyrene	1.8170	0.0033	0.7360	0.0003	0.29	0.00	
Dioxin Toxicity Equivalent	3.5716E-05	1.1935E-07	1.4467E-05	5.3902E-09	0.0000005	0.01	
Carbazole	0.3200	0.0972	0.1296	0.0001	No TRV	NA	
2-Butanone	0.0095	0.0029	0.0038	1.5401E-06	935	0.00	
Acetone	2.9230	0.8880	1.1840	0.0005	5.3	0.00	
Methylene chloride	0.0036	0.0011	0.0014	5.7753E-07	3.1	0.00	
NOTE: HQ = Hazard Quotient. mg/kg = Milligrams per kilogram. NA = Not available. NCBC = Naval Construction Battalion Center. TRV = Toxicity Reference Value.							

TABLE 14 STEP 3a REFINED FOOD-WEB RESULTS FOR THE AMERICAN ROBIN, NCBC DAVISVILLE SITE 16

Ecological Contaminant of Concern	Soil Concentration (mg/kg)	Vegetation Concentration (mg/kg)	Invertebrate Concentration (mg/kg)	Dose (mg/kg/day)	TRV (mg/kg/day)	HQ	HQ>1?
Chromium	9.164	2.7840	0.939	2.992	1	2.99	YES
Lead	77.736	0.8347	5.221	13.862	3.85	3.60	YES
Zinc	67.387	13.6742	58.837	60.516	14.5	4.17	YES
Benz(a)anthracene	3.516	0.0224	0.712	0.999	No TRV	NA	
Benzo(a)pyrene	1.857	0.0079	0.376	0.526	No TRV	NA	
Benzo(b)fluoranthene	5.846	0.0195	1.184	1.654	No TRV	NA	
Benzo(g,h,i)perylene	0.830	0.0015	0.168	0.234	No TRV	NA	
Benzo(k)fluoranthene	1.422	0.0004	0.288	0.401	No TRV	NA	
Chrysene	3.753	0.0239	0.760	1.066	No TRV	NA	
Fluoranthene	3.401	0.0548	0.689	0.980	No TRV	NA	
Indeno(1,2,3-cd)pyrene	1.817	0.0033	0.368	0.513	No TRV	NA	
Dioxin Toxicity Equivalent	5.967E-05	1.5754E-07	1.209E-05	1.687E-05	0.000014	1.20	YES
Carbazole	0.320	0.0972	0.065	0.130	No TRV	NA	
2-Butanone	0.009	0.0029	0.002	0.004	No TRV	NA	
Acetone	2.923	0.8880	0.592	1.187	No TRV	NA	
Methylene chloride	0.004	0.0011	0.001	0.001	No TRV	NA	
NOTE: HQ = Hazard Quotient. mg/kg = Milligrams per kilogram. NA = Not available. NCBC = Naval Construction Battalion Center. RV = Toxicity Reference Value.							

TABLE 15 SUMMARY OF SITE 16 RISK CALCULATIONS (HQs>1) IN ALL MEDIA FOR ALL ROCs

Analyte	Surface Soil Terrestrial Plants/ Invertebrates	Seep Water Marine Fish/ Plankton	Seep Sediment Marine Benthos	Conservative Food Web			Refined Food Web		
				Surface Soil Eastern Cottontail	Surface Soil Red Fox	Surface Soil American Robin	Surface Soil Eastern Cottontail	Surface Soil Red Fox	Surface Soil American Robin
INORGANICS									
Arsenic			4.5						
Barium		71.4	5.5						
Chromium	1.2					15.4			3.0
Cobalt		2.9							
Copper			3.7						
Lead	2.0		3.3	5.2	1.5	33.9			3.6
Manganese		25.4	3.0						
Nickel			2.6						
Selenium			1.3						
Zinc	1.7		2.3			7.8			4.2
PAH									
Acenaphthene			56.6						
Acenaphthylene			2.5						
Benzo(A)Anthracene	4.5			3.4	1.0				
Benzo(A)Pyrene	2.4			1.8					
Benzo(B)Fluoranthene	7.4			5.7	1.7				
Benzo[G,H,I]Perylene	1.1		2.2						
Benzo(K)Fluoranthene	1.8		1.4	1.4					
Chrysene	4.8		1.2	3.6	1.1				
Fluoranthene	4.3		3.0	3.1					
Fluorene			30.5						
Indeno(1,2,3-Cd)Pyrene	2.3		1.3	1.8					
Phenanthrene		1.5	3.3						
Pyrene			1.3						
PESTICIDE/PCB									
4,4'-DDD			1.7						
4,4'-DDT			1.8						
Dieldrin		10.5	85.0						
Endrin		1.7							
Endrin Ketone			80.0						
Gamma-Chlordane			3.4						

Analyte	Surface Soil Terrestrial Plants/ Invertebrates	Seep Water Marine Fish/ Plankton	Seep Sediment Marine Benthos	Conservative Food Web			Refined Food Web		
				Surface Soil Eastern Cottontail	Surface Soil Red Fox	Surface Soil American Robin	Surface Soil Eastern Cottontail	Surface Soil Red Fox	Surface Soil American Robin
Heptachlor			1.4						
Heptachlor Epoxide		5.6	2.4						
PCB-1260			1.6						
DIOXIN/FURAN									
Dioxin Toxicity Equivalent				20.1	5.9	7.2			1.2
VOC									
Acetone			13.8						
NOTE: HQ = Hazard Quotient. PAH = Polycyclic aromatic hydrocarbons. PCB = Polychlorinated biphenyls. ROC = Receptor of concern									